# CONTRIBUTION TO THE KNOWLEDGE OF THE BENTHIC ALGAL FLORA OF THE ISLE OF ALBORAN, WITH NOTES ON SOME LITTLE-KNOWN SPECIES IN THE MEDITERRANEAN

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ABSTRACT - The results of a floristic study of the benthic vegetation of the Isle of Alboran, based on collections made during two oceanographic cruises in the summer of 1988 and 1992, are presented. Altogether 35 new species for the Isle's flora are recorded; among them rare like *Desmarestia dresnayi*, *Polyneura bonnemaisonii* ? and *Polysiphonia setacea*, are rare or little-known in the Mediterranean. Data on morphology, ecology and geographical distribution of these species are presented and discussed from the biogeographical point of view.

RÉSUMÉ- Les auteurs présentent les résultats d'une étude floristique sur le phytobenthos de l'Ile d'Alboran effectuée au cours de deux campagnes océanographiques (été 1988 et 1992). Parmi les algues récoltées, 35 sont nouvelles pour la flore de l'île, parmi lesquelles 3 espèces rares ou peu connues en Méditerranées: *Desmarestia dresnayi*, *Polyneura bonnemaisonii* ? et *Polysiphonia setacea*. Des données concernant leur morphologie et leur écologie accompagnent ces signalisations. Leur significations biogéographiques sont discutées.

KEY WORDS - Floristic study, biogeography, Isle of Alboran, Mediterranean.

## INTRODUCTION

The Isle of Alboran is situated in the south western part of the Mediterranean (Sea of Alboran), close to the Atlantic Ocean. The influence of the Atlantic is reflected either by physical and biological traits that are peculiar for this part of the Mediterranean. Superficial currents come from the Atlantic through the Straits of Gibraltar; these currents reach the Sea of Alboran poorly mixing with mediterranean water (Cano, 1978a, 1978b). Therefore the Sea of Alboran represents a transition zone between the Atlantic Ocean and the Mediterranean Sea and these features have important implications from the biogeographical point of view (Flores & Conde, 1987; Conde-Poyales, 1989; Soto-Moreno & Conde-Poyales, 1993).

Although several floristic studies have been performed on the algal benthic communities of the Spanish and African coasts of the Sea of Alboran (Conde, 1984a, 1984b; Conde & Soto, 1986; Soto & Conde, 1989; Soto-Moreno, 1991; Gonzalez-Garcia & Conde, 1992; Gonzales-Garcia & Conde-Poyales, 1993) less attention has

been denoted to the submerged vegetation of the Isle of Alboran, probably because of its isolation (the isle is 88 km from Adra, Spain, and 53 km from Cape Tres Forcas, Morocco).

The first contributions to the algal flora of the Isle of Alboran date back to the end of the last century (Piccone,1884; Richard & Neuville, 1897); more recent studies include those of Pérès (1959), Esteve & Varo (1972), Giaccone (1972a, 1973), Giaccone & Bruni (1972-73), Garcia-Raso & Salas (1984), Sartoni & Boddi (1989), Ribera-Siguan & Soto-Moreno (1992), Sartoni (1992). The floristic data as a whole were summarized by Soto-Moreno & Conde-Poyales (1993), that mentioned in all 125 recorded taxa.

In the present work we report the results of a study on the benthic vegetation of the sublittoral zone of the Isle of Alboran, carried out during two oceanographic cruises in the summer of 1988 and 1992. Some new algae for the Alboran flora were recorded; the occurrence of some interesting species was also noted.

## MATERIALS AND [redacted]

Specimens were collected at several depths ranging from -16 m to -37 m in the August 1988 and in the August 1992 by SCUBA diving. They were stored in 5% formalin in sea water and examined in laboratory using a dissecting and [redacted] stereo microscope. The reproductive status of each species was qualitatively assessed.

Botanical nomenclature follows Gallardo *et al.* (1993) for the Chlorophyta, Ribera *et al.* (1992) for the Fucophyceae and fundamentally Giaccone *et al.* (1985) for the Rhodophyta, with some alterations suggested mainly by Maggs & Hommersand (1993).

## RESULTS

### Floristic list

We determined 72 species among which 5 Chlorophyta (7%), 14 Fucophyceae (19%) and 53 Rhodophyta (74%); 35 species were new for the algal flora of the Isle, according to the list of Soto-Moreno & Conde-Poyales (1993). Altogether 22 species (30%), 6 Fucophyceae and 16 Rhodophyta, showed reproductive structure; for 2 species of Rhodophyta (*Aglaothamnion byssoides* and *Hypoglossum hypoglossoides*) all the phases of the life history were observed. In the list asterisks denote new records for the Isle of Alboran; for species that were found fertile the reproductive structures are indicated.

CHLOROPHYTA

*Chaetomorpha aerea* (Dillwyn) Kützing
**Chaetomorpha mediterranea* (Kützing) Kützing
*Codium effusum* (Rafinesque) Delle Chiaje

*Ulva olivascens* Dangeard
*Ulva rigida* C. Agardh

FUCOPHYCEAE

*Carpomitra costata* (Stackhouse) Batters - unilocular sporangia
*Colpomenia sinuosa* (Mertens ex Roth) Derbès et Solier
*Cystoseira usneoides* (Linnaeus) Roberts
**Desmarestia dresnayi* Lamouroux ex Leman
*Dictyota dichotoma* (Hudson) Lamouroux var. *dichotoma*.
*Halopteris filicina* (Grateloup) Kützing
*Laminaria ochroleuca* La Pylaie.
**Myriactula rivulariae* (Suhr) J. Feldmann - unilocular sporangia
*Padina pavonica* (Linnaeus) Lamouroux - sporangia
*Saccorhiza polyschides* (Lightfoot) Batters
*Sargassum vulgare* C. Agardh - receptacles
*Sphacelaria cirrosa* (Roth) C. Agardh - unilocular and plurilocular organs, propagules
**Sphacelaria plumula* Zanardini
*Zonaria tournefortii* (Lamouroux) Montagne - sporangia

RHODOPHYTA

*Acrosorium venulosum* (Zanardini) Kylin
**Aglaothamnion byssoides* (Arnott et Harvey in Hooker) L'Hardy-Halos et Rueness - tetrasporangia, spermatangia, gonimoblasts
**Amphiroa cryptarthrodia* Zanardini - conceptacles
*Amphiroa rigida* Lamouroux - conceptacles
*Antithamnion algeriense* Verlaque et Seridi
*Antithamnion cruciatum* (C. Agardh) Nägeli var. *profundum* G. Feldmann
**Antithamnion heterocladum* Funk
**Aphanocladia stichidiosa* (Funk) Ardré
**Apoglossum ruscifolium* (Turner) J. Agardh
**Asparagopsis armata* Harvey - cystocarps
*Balliella cladoderma* (Zanardini) Athanasiadis
**Boergeseniella fruticulosa* (Wulfen) Kylin - tetrasporangia, cystocarps
*Callophyllis laciniata* (Hudson) Kützing
**Ceramium codii* (Richards) G. Feldmann
**Ceramium echionotum* J. Agardh
*Ceramium flaccidum* (Harvey ex Kützing) Ardissone
*Ceramium giacconei* Cormaci et Furnari - tetrasporangia
*Champia intricata* (Clemente) Cremades - tetrasporangia, cystocarps
*Corallina elongata* Ellis et Solander
*Crouania attenuata* (Bonnemaison ex C. Agardh) J. Agardh
**Cryptonemia lomation* (Bertolini) J. Agardh - tetrasporangia
**Dasya corymbifera* J. Agardh

**Dasya hutchinsiae* Harvey
*Dasya rigidula* (Kützing) Ardissone
**Erythroglossum sandrianum* (Zanardini) Kylin
*Erythrotrichia carnea* (Dillwyn) J. Agardh
"*Falkenbergia rufolanosa* (Harvey) Schmitz" stadium (sporophyte of *Asparagopsis armata* Harvey)
*Fauchea repens* (C. Agardh) Montagne
**Gracilaria bursa-pastoris* (Gmelin) Silva - cystocarps
**Halichrysis depressa* (Montagne *in* J. Agardh) Bornet - cystocarps
**Haraldia lenormandii* (Derbès et Solier) J. Feldmann - cystocarps
**Heterosiphonia crispella* (C. Agardh) Wynne
**Hydrolithon cruciatum* (Bressan) Y. Chamberlain
**Hypoglossum hypoglossoides* (Stackhouse) Collins et Hervey - tetrasporangia, cystocarps, spermatangia
*Kallymenia requienii* J. Agardh - gonimoblasts
*Liagora viscida* (Forsskål) C. Agardh
**Monosporus pedicellatus* (J.E. Smith) Solier in Castagne - monosporangia
*Jania rubens* Lamouroux - conceptacles
*Peyssonnelia coriacea* J. Feldmann
**Peyssonnelia* group *harveyana* P.L. et H.M. Crouan
*Peyssonnelia squamaria* (Gmelin) Decaisne
**Pleonosporium borreri* (J.E. Smith) Nägeli
**Plocamium cartilagineum* (Linnaeus) Dixon
**Polyneura bonnemaisonii* (C. Agardh) Maggs et Hommersand ?
**Polysiphonia setacea* Hollenberg
**Pterosiphonia parasitica* (Hudson) Falkenberg
*Pterothamnion crispum* (Ducluzeau) Nägeli - tetrasporangia
*Pterothamnion plumula* (Ellis) Nägeli
*Ptilothamnion pluma* (Dillwyn) Thuret *in* Le Jolis
**Scinaia interrupta* (De Candolle)Wynne
**Sebdenia rodrigueziana* (J. Feldmann) Parkinson
*Sphaerococcus coronopifolius* Stackhouse
*Stylonema alsidii* (Zanardini) Drew
*Stylonema cornu-cervi* Reinsch

## Observations

***Desmarestia dresnayi*** Lamouroux ex Leman
(Desmarestiaceae, Fucophyceae)

A sporophyte of *Desmarestia dresnayi* was collected at 37 m depth, on a gravel bottom where the algal covering was formed mainly by *Kallymenia requienii*; other species well represented in the area were *Halichrysis depressa, Peyssonnelia coriacea, Sebdenia rodrigueziana, Laminaria ochroleuca, Halopteris filicina, Carpomitra costata, Cryptonemia lomation.*

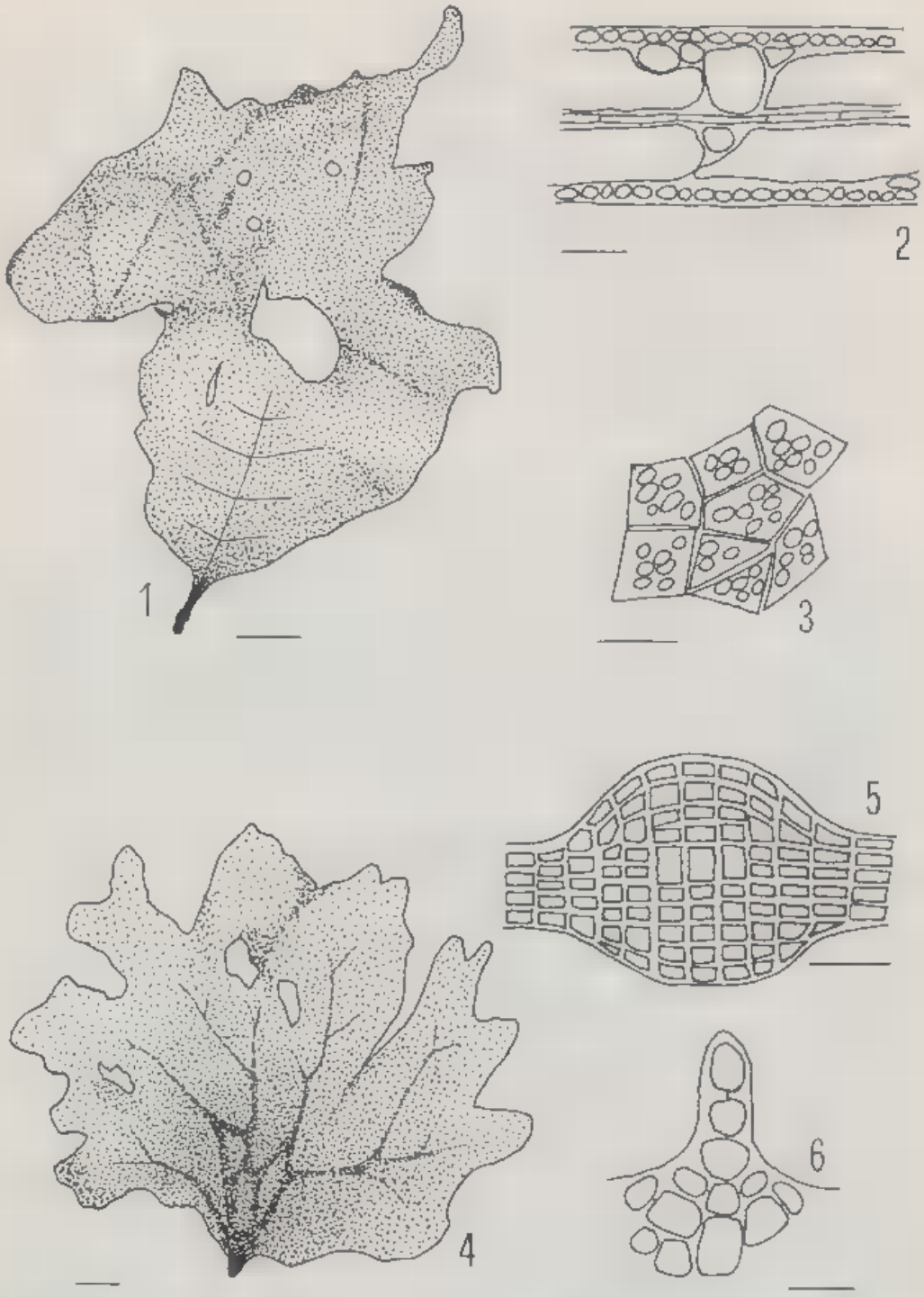



Fig. 1-3. - *Desmarestia dresnayi* Lamouroux ex Leman. Fig. 1. Habit. Scale bar = 10 mm. Fig. 2. Transverse section of the thallus. Scale: bar = 20 µm. Fig. 3. Surface view of the blade, showing cells with several discoid plastids. Scale: bar = 10 µm.
Fig. 4-6. *Polyneura bonnemaisonii* Maggs et Hommersand ? Fig. 4. Habit. Scale: bar = 10 mm. Fig. 5. transverse section of the blade in a macroscopic vein. Scale: bar = 180 µm. Fig. 6. A marginal tooth. Scale: bar = 20 µm.

*D. dresnayi* was attached to the substrate by a conical holdfast, from which a short (10 mm) stipe arised (Fig. 1). The thallus was about 100 mm high and 70 mm broad, and it looked ripped and perforated at the upper extremity; basally the blade showed a midrib starting from the stipe and branching into opposite, primary veins. In section (Fig. 2) the thallus was 60-70 µm thick and showed three layers: an outer epidermal layer was formed by 1 or 2 rows of bigger, varying in size, colourless cells and the innermost layer comprised a central axial filament. In surface view, superficial cells were polyhedric, generally rectangular, 10-15 µm long and 5-10 µm broad, and contained several discoid plastids without pyrenoids (Fig. 3); sporangia were not observed.

***Polyneura bonnemaisonii*** (C. Agardh) Maggs et Hommersand ?
(Delesseriaceae, Rhodophyta)

On a rocky bottom at 18 m depth, densely inhabited by *Sphaerococcus coronopifolius, Kallymenia requienii* and *Peyssonnelia squamaria*, we collected some sterile flattened red algal thalli which could belong to *Polyneura bonnemaisonii* (C. Agardh) Maggs et Hommersand. Other species of Delesseriaceae show ■ vegetative morphology close to *P. bonnemaisonii*; among them a similar geographical distribution is presented by *Erythroglossum laciniatum* (Lightfoot) Maggs et Hommersand (= *Polyneura laciniata* (Lightfoot) Dixon), but this species shows usually more deeply divided blades. Fertile material would be however helpful to confirm the determination [*P. bonnemaisonii* is different from *E. laciniatum* in the arrangement of the tetrasporangial and spermatangial sori and in the ornementation of the cystocarps, (Maggs & Hommersand, 1993)].

Fronds were epiphytized by *Pterothamnion plumula* and showed some perforations; they consisted of an expanded blade, fan shaped, about 100 mm tall and 70-100 mm broad (Fig. 4), terminal on a short (2-3 mm) stipe.

The blades were crossed by a network of polystromatic macroscopic veins starting from the base of the thallus and anastomosing, distally decreasing in microscopic veins. In mature parts, the fronds, formed by 4 cell layers, were about 180 µm thick, increasing up to 600 µm in the macroscopic veins (Fig. 5). Blade margins showed numerous denticulate proliferations; with apical cells transversely dividing (Fig. 6). In surface view polygonal cells, about 40 µm long and 30 µm broad, contained several plate-like plastids.

***Polysiphonia setacea*** Hollenberg
(Rhodomelaceae, Rhodophyta)

Some filaments of *Polysiphonia setacea* were observed on basal parts of *Zonaria tournefortii* and *Sphaerococcus coronopifolius* at 25 ■ depth. Collected specimens did not bear tetrasporangia, that are the only reproductive structure known in this species (Hollenberg, 1968); they were well characterized, however, by the whole of the following features:

- thalli of *P. setacea* formed an extensive system of prostrate axes, from which poorly ramified erect branches arised (Fig. 7, 8);

- prostrate axes were attached to the substrate by multicellular rhizoids (Fig. 9), cutting off as separate cells from the distal end of the pericentral cells in every segments (Fig. 11);

- in the erect branches pericentral cells were arranged in slightly oblique longitudinal rows (Fig. 12);

- filaments were about 70 µm thick (up to 100 µm in the mature prostrate axes);

- every cell contained numerous little, slightly elongate plastids, irregularly disposed;

- trichoblasts were 1-4 times dichotomously branched, abundant but fast deciduous (Fig. 13); falling, they left persistant scar-cells, arranged in ■ ¼ spiral sequence, one per segment in the erect parts, one every 1-3 segments in the creeping axes.

## DISCUSSION

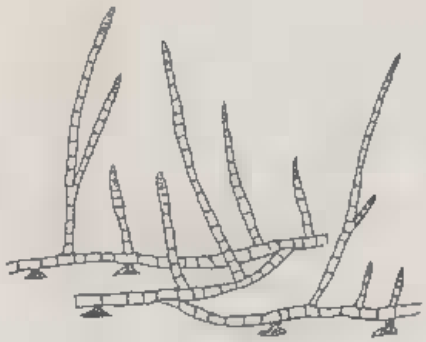
A total of 72 species were recorded in this study, 35 of which were new for the Isle of Alboran. Thus the floristic list increases from 125 (Soto-Moreno & Conde-Poyales, 1993) to 160 recorded taxa.

Among the new species only few (*Antithamnion heterocladum, Cryptonemia lomation, Sebdenia rodrigueziana*) have ■ geographical distribution restricted to the Mediterranean, while the most part is more or less widely diffused both in the Mediterranean and in the Atlantic. Some other species like *Desmarestia dresnayi* and *Polyneura bonnemaisonii* ?, common in the Atlantic, are instead rare in the Mediterranean.

*D. dresnayi* is a commonly diffused species in the Eastern Atlantic from Scotland to Northern Spain. In this area sporophytes of *D. dresnayi* live from May to September epilithic on small stones and shells embedded in gravels in the sublittoral, in areas of moderate to strong water current (Fletcher, 1987). In the Mediterranean, this species has been previously recorded only in the Straits of Messina (Drew & Robertson, 1974), where *D. dresnayi* occurs in areas characterized by cold waters and strong currents; particularly it was observed associated with *Laminaria ochroleuca*, between 60 m and 65 m depth (UNEP/IUCN/GIS Posidonie, 1990).

*P. bonnemaisonii* has been reported for the Northern Europe from Shetland Isles to Portugal (South & Tittley, 1986). Records of this species in the Mediterranean are few and uncertain (Giaccone, 1972b; Conde & Soto, 1986, as *Polyneura hilliae* (Greville) Kylin). In the Atlantic, blades of *P. bonnemaisonii*, annuals on perennial stipes, are common in the sublittoral up to 19 m depth, epilithic or epiphytic in the kelp forests, where this species is an usual epiphyte on the stipes of *Laminaria hyperborea* (Maggs & Hommersand, 1993).

Both *D. dresnayi* and *P. bonnemaisonii* seem to be species tolerant of strong hydrodynamism; at the Isle of Alboran these species find probably favourable habitats only on deep substrates, where typically atlantic communities occur, like kelp forests of *Laminaria ochroleuca*. In the Isle they were hitherto unknown probably because previous studies mainly concerned the shallow vegetation.



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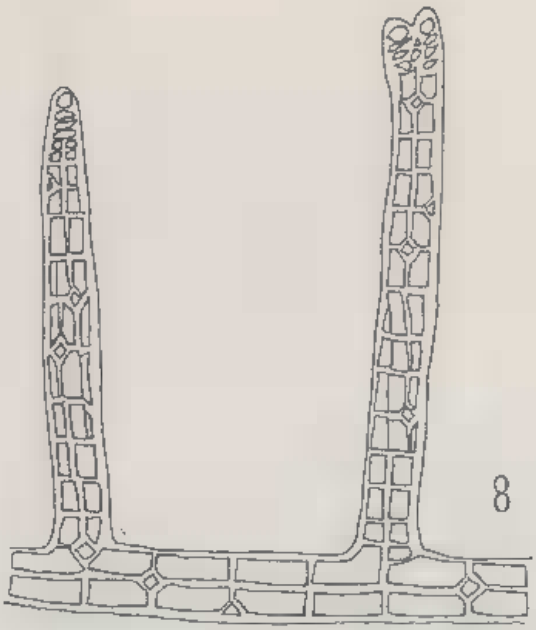

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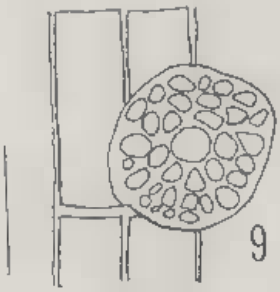

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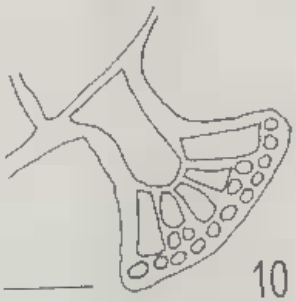

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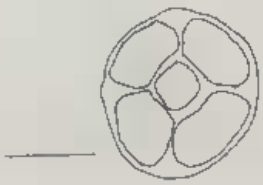

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*Polysiphonia setacea* is a widely diffused species in the tropical zones of the Pacific and Atlantic Oceans (Hollenberg, 1968; Oliveira-Filho & Cordeiro-Marino, 1970; Egerod, 1971; Schnetter & Bula-Meyer, 1982; Wynne, 1986). In the Mediterranean, *P. setacea* was first recorded by Verlaque (1989) on Var (Southern France) coasts; later this species was also found in Corse (Verlaque, 1990), in several localities of North Western Italy (Airoldi *et al.*, 1994) and at the Isle of Lampedusa (Sicily Channel) (Cormaci *et al.*, 1993). Recently some filaments of *P. setacea* were recognized in material coming from Palinuro (South Western Italy) and Milos (Aegean Sea, Greece) (Rindi, pers. observ.). At the Isle of Alboran this alga is represented only by few epiphytic filaments and does not seem as abundant as in other areas of the Mediterranean. In the subtidal south of Livorno (Western Italy), for example, this species occurs throughout the year and it dominates the substrate from 10 m to 40 m depth. Previous works in this [redacted] (Airoldi *et al.*, in press) suggest that *P. setacea* by forming a dense turf may inhibit the recruitment of other algae. A similar phenomenon was observed in the region of Galeria (Corse) (Rodriguez Prieto *et al.*, 1993). According to Verlaque (1989), *P. setacea* would have been accidentally introduced in the Mediterranean; at present, because of the amplitude of its known distribution area and the density of its populations, it seems well acclimatized and in phase of expansion. The Alboran record is so far the most western, and it seems that by now this species is largely diffused in the Western Mediterranean.

From the biogeographical point of view, we observed an abundant occurrence of both mediterranean taxa like *Kallymenia requienii*, *Peyssonnelia coriacea*, *Peyssonnelia squamaria*, *Sebdenia rodrigueziana*, and of species typical of Atlantic European shores, like *Cystoseira usneoides* and *Saccorhiza polyschides* in the shallow vegetation, and *Carpomitra costata* and *Laminaria ochroleuca* more deeply. These results are consistent with previous observations of other authors, emphasizing the atlantic affinities of the algal flora of the Isle of Alboran (Cinelli, 1985; Flores & Conde, 1987; Soto-Moreno & Conde-Poyales, 1993); more generally, they seem highlight the importance of the Alboran Sea as a transition zone between the Atlantic and the Mediterranean and point out the key position of the Isle of Alboran, as observed by Conde-Poyales (1989). This author, considering hydrological data of Cano (1978a, 1978b), suggests that the Isle would lie on the borderline between a western sector and an eastern one, respectively characterized by different phytogeographical affinities. Further studies, more detailed and extended to an annual cycle, are however necessary to evaluate this hypothesis and to obtain a more accurate floristic and ecological characterization of the area.

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Fig. 7-13. *Polysiphonia setacea* Hollenberg. Fig. 7. Habit. Scale: bar = 500 µm. Fig. 8. Detail of [redacted] prostrate axis showing two young erect branches. Scale: bar = 100 µm. Fig. 9. Multicellular tip of a rhizoid. Scale: bar = 90 µm. Fig. 10. A multicellular rhizoid, cutting off [redacted] a separate cell from the distal end of a pericentral cell. Scale: bar = 50 µm. Fig. 12. Detail of an erect branch showing cells rows obliquely arranged. Scale: bar = 40 µm. Fig. 13. Apical portion of an erect branch bearing trichoblasts. Scale: bar = 70 µm.

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